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Nuclear Experimental Group I

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Research Activities

(I) LIGHT ION NUCLEAR PHYSICS

a. Isoscalar LEOR in Deformed Nuclei (T. Tohei, J.I. Hirota, T. Nakagawa, T. Saito, Y. Hozumi, O. Satoh and M.H. Tanaka)

The splitting of the resonance strength by K-components in the isoscalar LEOR has been studied in inelastic α-scattering at $E_\alpha = 65$ MeV on deformed nuclei, ^{156}Gd, ^{164}Dy, ^{172}Yb and Sm isotopes. The double bumps in the deformed nuclei ^{156}Sm and ^{154}Sm have been observed that the upper one corresponds to the LEOR strengths for K = 1 and 3 components, while the lower one to the ones for K = 0 and 2 components. The splitting behaviour of these bumps varies substantially over a small change in masses A between ^{154}Sm and ^{144}Sm.

b. Discrimination between $\ell = 1$ and $\ell = 3$ Transfer in the LEOR Region (T. Tohei, J.I. Hirota, T. Nakagawa, T. Saito, Y. Hozumi and M.H. Tanaka)

The $\ell = 1$ transitions of the α-particle scattering were able to be discriminated from the $\ell = 3$ transition in the LEOR region by the measurements of the angular distribution at forward angles. To eliminate the elastically scattered α-particle from contaminated hydrogens at the forward angle, scattered α-particles were detected with a proportional counter combined with the QDD magnetic spectrograph in anti-coincidence with recoil protons. In ^{60}Ni α particles from hydrogen were reduced to 1.6 % at $\theta = 5°$ by this method.

c. Nuclear States of ^{28}Si from (d, n) Reaction at 25 MeV (T. Tohei, T. Nakagawa, J.I. Hirota, T. Kawamura, S. Morita, A. Sato, . Ishimatsu, H. Orihara, K. Miura and H. Ohnuma)

Angular distributions for the ^{27}Al(d, n)^{28}Si reaction have been measured by the TOF-technique with a 25 MeV deuteron beam. In the transition to the

unbound states angular distributions for 4^-, 5^- and 6^- T = 0 and 1 states display the characteristics of an $\ell = 3$ transfer, except for the bound 4^- state corresponding to the ideal $\ell = 3$ transfer.

d. Cross Section and Analyzing Power Measurement for the (p, d) Reactions on ^{28}Si and ^{40}Ca (H. Ohnuma, C.A. Whitten, F. Irom, B. Aas, G.J. Igo, T. Nakagawa, M. Gazzaly and K. Jones)

The cross sections and analyzing powers for the (p, d) reactions on ^{28}Si and ^{40}Ca have been measured with the 500 MeV polarized proton beam at LAMPF, using the high resolution spectrometer (HRS).

(II) INELASTIC ELECTRON SCATTERING

a. LEOR in ^{62}Ni (T. Tohei, J.I. Hirota, T. Saito, K. Saito, Y. Fujii, Y. Hozumi and Y. Torizuka)

Inelastic electron scattering for ^{62}Ni in the LEOR region has been studied in the effective momentum transfer range $0.65 \leq q_{eff} \leq 1.18$ fm^{-1}. In this region strong transitions for E4 and E5 components have been discussed in comparison with the ^{62}Ni(α, α') data at $E_\alpha = 65$ MeV.

b. Giant Multipole Resonance in Deformed ^{154}Sm (T. Tohei, J.I. Hirota, T. Saito, Y. Hozumi, Y. Fujii and Y. Torizuka)

Giant-resonance regions in deformed ^{154}Sm have been studied by inelastic electron scattering in the effective momentum transfer range $0.52 \leq q_{eff} \leq 1.05$ fm^{-1}. Double bump in the LEOR was discussed in comparison with the (α, α') results at $E_\alpha = 65$ MeV.

c. Observation of the Nuclear Isovector Monopole Resonance (Y. Torizuka, T. Saito, M. Oyamada, H. Ogino, Y. Hozumi, J. Yokokawa, J.I. Hirota and T. Tohei)

To study the existence of a collective isovector monopole excitation in a nucleus a preliminary study of electron scattering from ^{208}Pb has been done at $E_e = 220$ MeV and $\theta_L = 30°$. The data suggest that the broad bump at $E_x \sim 34$ MeV would correspond to the isovector monopole resonance.

(III) POLARIZATION

a. Measurements of the Wolfenstein Parameters for the (p, p) and (p, p') Scattering on ^{2}D, ^{3}He, ^{9}Be, ^{16}O and ^{40}Ca at Intermediate Energies (G.J. Igo, B. Aas, D. Adams, A. Azizi, E. Bleszynski, M. Bleszynski, D. Lopiano, T. Nakagawa, H. Ohnuma, G. Pauletta, A. Rahbar, F. Sperisen, J. Wagner, G.S. Weston, A.T.M. Wang, C.A. Whitten, K.W. Jones and J.B. McClelland)

Measurements of elastic and inelastic scattering for the ^{2}D, ^{3}He, ^{9}Be,

^{16}O and ^{40}Ca targets have been done with 300 ∿ 800 MeV ℓ, s and n-type proton beams at LAMPF, using a focal plane polarimeter on the HRS.

b. Spin-orbit Coupling in the (d, ^{6}Li) Reaction (T. Yamaya, J.I. Hirota, K. Takimoto, S. Shimoura, A. Sakaguchi, M. Fukada, S. Kato, S. Kubono, M. Sugitani and T. Suehiro)

For a systematic study of the α-cluster structure in the nuclei of the mass $A \leq 94$ differential cross sections and analyzing powers have been measured with vector polarized deuterons at $E_d = 51.7$ MeV for the targets of ^{12}C, and ^{13}C nuclei. This was done in order to understand clearly a spin-orbit coupling effect in the (d, ^{6}Li) reaction. It becomes evident that the spin-orbit part in the deuteron optical potential plays a major role in the analyzing power for the (d, ^{6}Li) reaction, but this part of the ^{6}Li optical potential has a minor effect.

c. Unbound Core Effect for the α-pickup Reaction (T. Yamaya, J.I. Hirota, K. Takimoto, S. Shimoura, A. Sakaguchi, M. Fukada, S. Kato, S. Kubono, M. Sugitani and T. Suehiro)

In the α-pickup reaction from the ^{12}C and ^{16}O targets, the cores of the target nuclei are assumed to be in unbound states in transitions leading to the ground state (0^+) of ^{8}Be and the 7.6 MeV state (0^+) of ^{12}C. The analyzing powers for the ground state of ^{12}C show large negative values near the angle $\theta_{cm} \sim 35°$, contrary to those for the unbound states.

(IV) NUCLEAR PHYSICS BY HIGH-RESOLUTION (p, n) EXPERIMENTS

(H. Orihara, S. Nishihara, K. Furukawa, M. Kabasawa, T. Kawamura, Y. Takahashi, T. Nakagawa, K. Maeda, K. Miura, C.D. Zafiratos, G.C. Kiang, D. Dehnhard and H. Ohnuma)

The charge exchange (p, n) study, by establishing the existance of the Gamow-Teller resonance, which is regarded to be one of the most fruitful research fields of current nuclear physics, appears to be entering a new phase where it is used to investigate following physical interests: (1) effective nucleon-nucleon interactions (2) properties of magnetic states such as 0^-, 1^+, 2^-, 3^+..... excited by the spin-isospin mode including stretched states (3) Gamow-Teller strength distributions for the solar neutrino and for the galactic neutrino experiments etc..

a. Londitudinal Spin Response Observed in the $0^+ \rightarrow 0^-$ like Charge-exchange (p, n) Reactions

Charge-exchange (p, n) reactions present a place to work with isovector spin-response in nuclei when $0^+ \rightarrow 0^-$ or $1/2^- \rightarrow 1/2^+$ transitions are observed. We have measured angular distributions of differential cross sections for neutrons emitted from (p, n) reaction on ^{13}C, ^{14}C and ^{16}O. Due to the char-

acteristic feature of this transition, the effects of p-h tensor interactions were clearly seen, while an enhancement of the cross section was found at large momentum transfer ($1.0 \leq q \leq 2.0$ fm^{-1}).

b. Low-energy (p, n) Cross Sections in A = 58-71 and Gamow-Teller Strength

Angular distributions for the ground states have been measured at $E_p = 20$ MeV in the (p, n) reactions on ^{58,64}Ni, ^{68,70}Zn and ^{71}Ga. The 0° cross sections, corrected for the distortion effects, are found to be proportional to B(GT) values obtained from the known β-decay log ft values.

c. Excitation of $\Delta L = 1$, $\Delta S = 0$ Giant Resonances in the (p, n) Reactions on ^{90}Zr, ^{120}Sn, ^{140}Ce and ^{208}Pb at $E_p = 41$ MeV

In the ^{90}Zr, ^{120}Sn, ^{140}Ce, ^{208}Pb(p, n) reactions at $E_p = 41$ MeV a broad peak was systematically observed at about 10 MeV above the Gamow-Teller resonance. The cross sections and angular distribution shapes of these peaks are consistent with an interpretation that they are mainly $\Delta L = 1$, $\Delta S = 0$ states predicted by a TDA calculation with a Skyrme type interaction.

(V) HEAVY ION NUCLEAR PHYSICS

a. Spin-orbit Potential for ^{14}N Elastic Scattering at 84 MeV (T. Yamaya, K. Kotajima, T. Shinozuka, M. Fujioka, S. Morita, O. Satoh, J.I. Hirota, K. Satoh, T. Ohi and T. Washio)

Effect of a spin-orbit potential on the angular distribution has been experimentally observed from a comparison between angular distributions of the ^{14}N+^{28}Si and ^{16}O+^{28}Si elastic scattering at 84 MeV and 81 MeV incident energies, respectively.

b. Elastic and Inelastic Scattering of 84 MeV ^{14}N Ions on Light Target Nuclei (T. Yamaya, K. Kotajima, T. Shinozuka, M. Fujioka, S. Morita, O. Satoh, J.I. Hirota, K. Satoh, T. Ohi and T. Washio)

Differential cross sections of elastic and inelastic scattering of ^{14}N have been measured for the ^{9}Be, ^{12}C, ^{13}C, and ^{28}Si targets. The calculation of coupled channels is expected to reproduce the data. The deformation parameters β_2 were deduced.

c. Target Dependence of the (^{16}O, α) Reaction at 145 MeV (K. Nagatani, T. Yamaya, T. Shimoda, N. Takahashi, T. Murakami, S. Shimoura, T. Fukada and K. Katori)

The inclusive alpha spectra and α-^{12}C, α-^{16}O correlations in the (^{16}O, α) reaction at 145 MeV were measured for the ^{12}C and ^{13}C targets in the same detection geometry. It was suggested that the target dependence of the (^{16}O, α) reaction does not conflict with the interpretation of α-sequential decays from ^{20}Ne- and ^{16}O-excited states depended on these structures.

(VI) INSTRUMENTATION AND SYSTEM DEVELOPMENT

a. Data Acquisition System for Heavy Ion Experiments (O. Satoh and T. Yamaya)

Four AD-converters were connected with a DRU11 branch driver of a PDP/44 computer by means of a multi-channel interface that was recently designed and assembled. This data taking system was very useful for heavy ion experiments.

b. Achromatic Beam Transport for Light Particles and Heavy Ions at the Tohoku Cyclotron (T. Yamaya, T. Shinozuka, K. Kotajima and M. Fujioka)

Achromatic beam transport was successful for the high resolution beam course of the Tohoku University cyclotron. About 50 times beam intensity was obtained at the target position for 10 MeV protons and 84 MeV nitrogen ions.

c. Thick-method Neutron Counter for High Energy Neutron (T. Suehiro, T. Yamaya, K. Kotajima, K. Miura, S. Kato, S. Morita and O. Satoh)

Thick-method neutron counter was designed and assembled for measurements of analyzing power A_y or a spin flip probability K_y^y in the (p, n) reaction. This counter consists of a scintillation counter as a proton conversion target, a proton transmission solid state detector and a stopping solid state detector.

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10) Systematic study of the α-spectroscopic factor in the (d, Li) reaction on $12 \leq A \leq 94$ nuclei, T. Suehiro, T. Yamaya, K. Takimoto, R. Wada, E. Takada, S. Shimoura, A. Sakaguchi, S. Murakami, M. Fukada and Y. Okuma, 4th Int. Conf. on Clustering Aspects of Nuclear Structure and Nuclear Reaction, Chester (1984).

11) Unbound core effect for the α-pickup reaction, T. Yamaya, J.I. Hirota, K. Takimoto, S. Shimoura, A. Sakaguchi, M. Fukada, S. Kato, S. Kubono, M. Sugitani and T. Suehiro, 4th Int. Conf. on Clustering Aspects of Nuclear Structure and Nuclear Reaction, Chester (1984).

Doctor Thesis (March 1984)

D1) Particle-hole collective states in ^{140}Pr studied by the reaction ^{140}Ce (p, n)^{140}Pr, Susumu Nishihara.

Master Thesis (March 1984)

M1) Elastic and inelastic scattering of heavy ions from light nuclei, Susumu Morita.